**Objectives**

* Describe how energy drives movement and change in the hydrosphere and atmosphere. You should also be able to predict circulation in the atmosphere and hydrosphere may change due to global warming.

**Causal Principles**

1. Gravitational energy, thermal energy and/or chemical **energy** drive all movement and change of matter on Earth.

3. Matter moves and changes to return a system to **equilibrium.**

1. **Temperature** is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
2. When molecules move faster, the **density** of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
3. **Buoyancy** causes materials to rise or fall due to the relative density of materials.

**PART 1: Background Notes**

Describe below how temperature affects the density of air and water and how salinity affects the density of water:

The density of air is determined by the temperature of the air’s surroundings. If the temperature is high, the molecules in the air move faster. If the surrounding temperature is cold, the air molecules will move slower.

The density of water is affected by salinity because the salt ions are dissolved in the water, therefore take up space between the water molecules. The salt ions also interact with the water’s surface tension and weaken it.

**Part 2: Group Work – Thermohaline Circulation**

Complete Table A as we did in class. Fill in the causal principles that are associated with each feature of the atmosphere. Use the causal principles listed at the beginning of this activity.

|  |  |
| --- | --- |
| **Table A. Causal Principles and the Atmosphere** | |
| **Atmosphere** | **Principle** |
| Hot and cold regions | Temperature, Movement to obtain equilibrium, density |
| Heat from the ground | Thermal energy, Temperature, movement |
| Hot and cold air | Thermal energy, Temperature, movement, buoyancy |
| Hadley cells | Thermal energy, Temperature, movement,  Buoyancy, density, movement |

Complete Table B like we did during the class example. *One of the features in Table B does not correspond to a principle that causes thermohaline circulation*. Write ***no principle*** in that box in the table.

|  |  |
| --- | --- |
| **Table B. Causal Principles and the Oceans** | |
| **Oceans** | **Principle** |
| Hot and cold regions | Temperature, movement, density, buoyancy |
| Heat from the ocean surface | No principle |
| Hot and cold water | Thermal energy, movement, Temperature, buoyancy |
| Cold saltier water in polar regions | Temperature, Density, movement |

In Table C, fill in the corresponding features for the ocean that matches with the atmosphere. *There can be more than one possible match or no match at all.* Fill in everything you can and the corresponding principles.

|  |  |  |
| --- | --- | --- |
| **Table C. Comparing Atmosphere and Ocean Circulation** | | |
| **Atmosphere** | **Ocean** | **Principle** |
| Hot and cold regions |  | Density, thermal energy, temperature, buoyancy |
| Heat from the ground |  | No match |
| Hot and cold air |  | Movement, buoyancy, density, temperature, thermal energy |
| Hadley Cell |  | No match |

In Table D, fill in the differences between atmosphere and ocean circulation.

|  |  |  |
| --- | --- | --- |
| **Table D. Differences Between Atmosphere and Ocean Circulation** | | |
| **Difference** | **Atmosphere** | **Oceans** |
| Features related to density | As air cools it becomes denser. Adding substances to air may make it less dense. | Water becomes less dense from 4°C to 0°C. Adding substances to water tends to make it denser. |
| Primary source of energy for movement | Solar energy, long wave infrared from earth surface | Solar energy, air removes heat from water |

**Part 3: Homework**

If you complete the group work, you may work on the homework **on your own.** This means your answers should be generally unique from other students’ answers. **Submit your homework using ANGEL**.

**True or False**:

1. The ocean circulation transfers heat to the polar regions.

*TRUE*

Explain the reasoning for this answer:

Equatorial warm water is taken by westerly currents pole-ward to try and reach thermal equilibrium.

2. During ocean circulation, warm water rises in the equatorial regions.

*TRUE*

Explain the reasoning for this answer:

Warm water (greater than 4°C) is lighter than cooler water. Thermal energy is greatest in the equatorial region.

**Short Answer**

3. What factors can cause the circulation of air and/or water?

Density changes driven by temperatures will cause circulation in air and water. Both air and water want to reach equilibrium and this movement also contributes to circulation.

4. How might global warming impact the circulation of fluids? (There are multiple correct answers for this question.)

The heating of the atmosphere will make the temperature differences smaller and might slow down or eliminate circulation. With the possibility of decreases in density, there might be less vertical movement. With water, an increase in temperature means a decrease in the ability to dissolve gases like CO2, but an increase in the ability to dissolve solids, like salt.